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monthly survey by the U. S. National Committee for the International Geophysical Year. Established by and part of the National Academy of Sciences, the Committee is responsible for the U. S. International Geophysical Year program in which several hundred American scientists are participating and many public and private institutions are cooperating.

Status of Special Studies in Meteorology

The following report is based on material supplied by Sigmund Fritz, Lester Hubert, J. A. Humphrey, R. J. List, T. W. Machta, J. H. McDonald and W. B. Moreland, US Weather Bureau; C. D. Keeling, Scripps Institution of Oceanography; R. G. Leahy, Woods Hole Oceanographic Institution; and J. R. Ibert and D. W. Hood, Texas A&M College.

The IGY prompted an increase in the US Weather Bureau's extensive program of standard meteorological measurements of temperature, pressure, wind speed and direction, precipitation, etc. In addition, the US Weather Bureau also conducted a series of special meteorological studies during the IGY. These dealt with incoming and reflected solar radiation; ozone, CO_2, and other atmospheric constituents; nuclear "tracer" materials in the air; and aerial meteorological reconnaissance in tropical regions.

This report summarizes the aims and some of the findings to date of these investigations.

Solar Radiation

The geographically uneven absorption by the earth and its atmosphere of radiative energy is a major cause of the general atmospheric circulation. From the tropics to the middle latitudes, more solar radiation is absorbed than is lost by re-radiation; poleward from these latitudes more radiation is lost than received. The resulting net warming in the tropics and net cooling in polar regions motivates the global circulation.

Our knowledge of solar energy, absorption and re-radiation, and of radiation exchanges in the atmosphere, has been quite limited. In general, visible and short-wave solar radiation penetrates the atmosphere to the earth's surface, where it is absorbed and radiated again in long waves, mainly in the infrared region of the spectrum. Water vapor, CO_2, and ozone in the air absorb most of the out-going infrared radiation and return it once again to the earth. As part of the IGY program, the US Weather Bureau measured solar radiation and long-wave radiation at six stations in Antarctica and on two drifting ice stations in the Arctic Ocean. The Wilkes Station in Antarctica also had a sub-station on the inland ice 50 mi to the east-southeast at an elevation of about 3700 ft. Similar measurements were taken at a newly-established observatory 11,150 ft above sea level, at Mauna Loa, Hawaii (19° N, 155° W).

The elements measured were the intensity of total solar and sky radiation on a horizontal surface, intensity of the direct solar beam, natural illumination, albedo, or reflectivity, of the earth's surface, hemispherical radiation (from above), and net radiation (incoming minus outgoing). The solar beam appears to be depleted to a much

smaller extent in the Antarctic and at Mauna Loa, where the atmosphere is purer, than at the two continental United States stations.

Studies at Drifting Station Alpha in the Arctic Ocean (see *Bulletin No. 12*) indicate the great importance of long-wave radiation from the overcast sky in the melting of snow and ice. During the melt season, melting proceeds much more rapidly under the overcast than it does with clear skies and bright sunshine; with clear summer skies, in fact, refreezing may occur.

Ozone

The ozone concentration in the earth's atmosphere increases vertically, reaching a maximum in a layer which may lie between heights of about 12 and 22 mi, depending on time and latitude. The amount of ozone in any vertical column in the atmosphere varies with changes in the atmospheric circulation. Hence, measurements of the distribution and variations of ozone at the surface and in the lower levels of the atmosphere provide clues to the vertical and horizontal motions of the lower stratosphere. Moreover, ozone is thought to be responsible for the large annual temperature variation in the stratosphere above the polar regions.

Ozone measurements were made by the Weather Bureau during the IGY at stations in the continental United States, in the Arctic and Antarctic, and in Hawaii. Prior to the IGY, ozone measurements for the Antarctic were completely lacking.

Surface Ozone at Mauna Loa, Hawaii: Continuous recordings of surface ozone at the Weather Bureau's Mauna Loa Observatory have been made since August 1957 with automatic chemical sampling equipment developed by V. H. Regener at the University of New Mexico.

The first 14 months' records indicate that the variations in surface ozone at Mauna Loa are related to both local and large-scale features of the atmospheric circulation.

A marked seasonal variation is evident with a spring maximum and an autumn minimum of surface and total ozone similar to those found elsewhere. Monthly means ranged from 33 micrograms/m³ in October 1957 to 68 in April 1958, the rise being especially steep from late winter to early spring. The lowest mean hourly value observed was about 20 micrograms/m³ and the highest near 100.

Superimposed upon these seasonal trends and often of comparable amplitude, is a pronounced daily variation, with morning maxima (a secondary peak is common shortly after sunrise) and mid-afternoon minima (see Fig. 1). This is attributed to

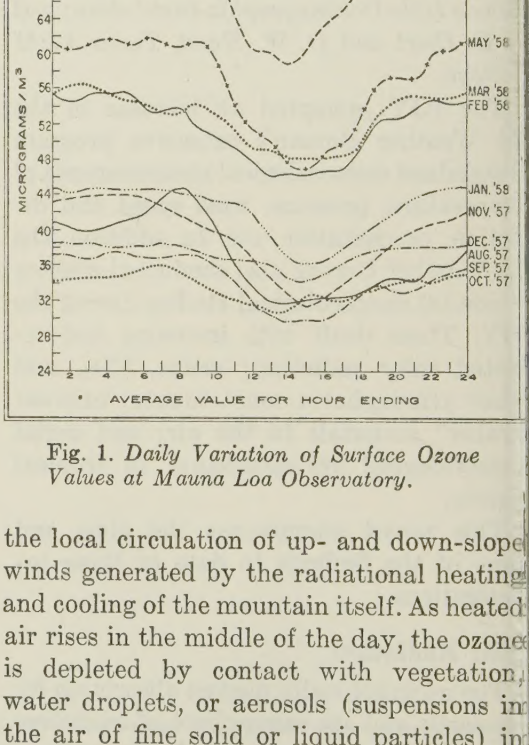

Fig. 1. *Daily Variation of Surface Ozone Values at Mauna Loa Observatory.*

the local circulation of up- and down-slope winds generated by the radiational heating and cooling of the mountain itself. As heated air rises in the middle of the day, the ozone is depleted by contact with vegetation, water droplets, or aerosols (suspensions in the air of fine solid or liquid particles) in the moist sub-inversion layer (below about 6500 ft).

Striking variations in the amount of surface ozone have also been observed to ac-

ompany changes in the broad circulation atterns of the Pacific area. Ozone increased bruptly with the transition from the prevailing trade-wind regime to a strong westrly flow around deep cyclones centered orth of the Hawaiian Islands; it decreased gain with the return of the trade winds.

Total Ozone at Mauna Loa: The Obervatory's Dobson spectrophotometer was ut into operation on November 27, 1957. 'his instrument determines depth of atiospheric ozone from the differential abprption by ozone of two spectral lines in ie ultraviolet portion of the solar beam. 'he elevation of this particular instrument the highest permanent installation of its ind in the world) and the clarity of the verlying atmosphere make its observations specially valuable for calibration purposes, rincipally in estimating solar radiation itensities outside the atmosphere.

Day-to-day variations in total ozone at Mauna Loa appear to be small; however, ie actual amounts of ozone and the amplide of the seasonal variation are high for iat latitude. The amount varied from .250 m in February 1958 to .288 in May. (Total zone is measured in terms of the total ickness of ozone computed for an atmosheric column compressed to sea-level pres-ire.) These values, as well as the observaon of a seasonal peak later than that in iiddle and high latitudes, require further onfirmation.

Surface Ozone at IGY Little America tation, Antarctica: Surface observations

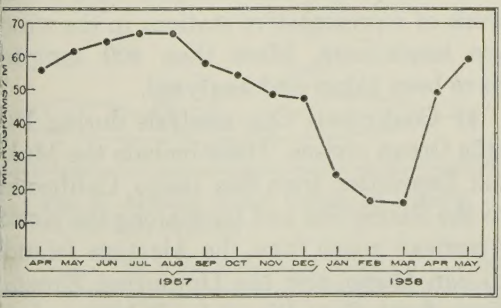

Fig. 2. *Mean Monthly Surface Ozone Values at IGY Little America Station.*

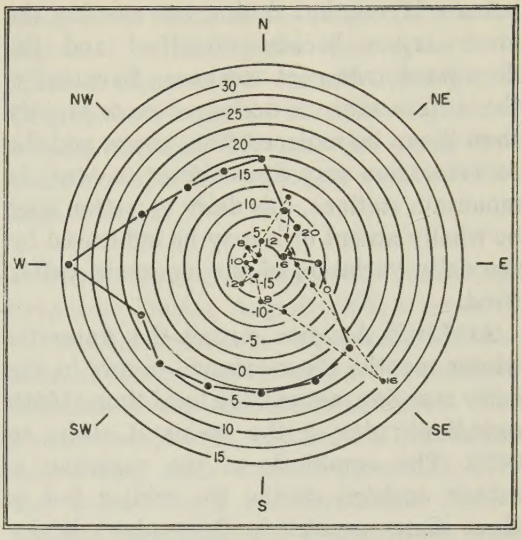

Fig. 3. *Surface Ozone and Wind Roses for IGY Little America Station, June 1957. Dashed line and lighter circles represent wind-direction frequency in percent of total time; solid line and heavier circles represent surface ozone in percent deviation from monthly average of 64 micrograms/m³ of air. Winds were calm 5.4% of the time, during which surface ozone deviated + 9.5%.*

at Little America Station (78°S, 162°W) were made with the Regener chemical surface-ozone recorder. A marked feature of the annual variation (Fig. 2) is the rapid rise of ozone values in April, when the sun disappears, and the slow decrease beginning in September, after the sun returns.

The dependency of surface ozone content on wind direction is shown in Figure 3. Positive deviations from the average ozone concentration occur when the wind direction has a westerly component and negative deviations occur when it has an easterly component.

The daily variation of surface ozone concentration at Little America differs markedly from that in middle latitudes. Middle latitude stations usually report a maximum in late morning or early afternoon and a minimum in the late evening or early morning, believed to result from change in the vertical mixing caused by turbulence. In the afternoon, convective activity permits the ozone to be carried down from the up-

per air layers, but during the evening the lower layers become stratified and the downward transport weakens. Eventually, the surface ozone is destroyed more rapidly than it can be replaced from above and the concentration may drop almost to zero. At mountain stations, this daily variation may be wholly absent or it may be influenced by the daily variation of the mountain-valley wind.

At Little America during the Antarctic winter months the maximum occurs in the early morning, about 0300 local time (165th meridian); during the spring it shifts to 0600. The amplitude of the variation is rather uniform during the winter but is three times greater in September; it decreases again in the spring. (See Table 1.)

TABLE 1

Harmonic Analysis of Daily Variations in Ozone Concentration at Little America during 1957

Month	Amplitude* (Micrograms/m³)	Time of Maximum Departure (hours after midnight)
April	2.7	2.0
May	0.6	2.1
June	2.2	2.6
July	2.0	2.9
August	1.9	2.7
September	6.1	2.9
October	2.6	4.0
November	1.2	5.5

*Average value of maximum daily departure from monthly mean value

Total Ozone at Little America Station: Observations of total ozone at Little America (Fig. 4) indicate that two maxima may occur—one during the winter and the other in late spring. The winter maximum must be confirmed by additional observations. The rise of total ozone toward the winter maximum begins one month later than that for surface ozone.

Carbon Dioxide

Air temperatures in the lower levels of the earth's atmosphere may be controlled to a large extent by the amount and distribution of CO_2 in the atmosphere, for CO_2 absorbs much of the energy radiated outward from the earth and radiates it back to the surface. The IGY CO_2 program has attempted to determine the present amount and distribution of CO_2 in the atmosphere as well as any evidence of long-run changes.

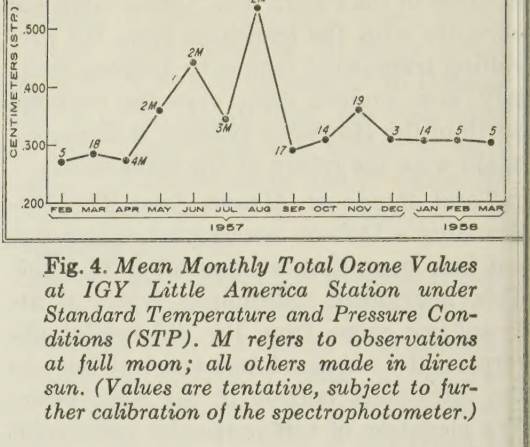

Fig. 4. *Mean Monthly Total Ozone Values at IGY Little America Station under Standard Temperature and Pressure Conditions (STP). M refers to observations at full moon; all others made in direct sun. (Values are tentative, subject to further calibration of the spectrophotometer.)*

Scripps Institution of Oceanography Program: Scripps Institution of Oceanography, which had major responsibility for IGY CO_2 analysis, employed the following four methods of investigation:

1) Continuous analysis of CO_2 concentrations at points where local (industrial) influence is minimal—Little America Station, Mauna Loa Observatory, and Scripps' own location, La Jolla, California.

2) Analysis of flask samples taken at the 500-mb level (about 18,000 ft) over the Pacific Ocean on US Air Force Weather Service reconnaissance flights. Eighty-four samples were taken on seven flights.

3) Analysis of flask samples from a network of representative stations in the western hemisphere. More than 400 samples have been taken and analyzed.

4) Continuous CO_2 analysis during Pacific Ocean cruises. These include the Mukluk Expedition from San Diego, California, to the Bering Sea and back along the North American coast from the Aleutian Islands to San Diego, and the Downwind Expedition, from San Diego to Tahiti and to Valparaiso, Chile (see *Bulletin No. 7*).

The program was made possible by the availability of a new, non-dispersive infrared gas analyzer with a precision of ± 0.2 parts per million of CO_2 in normal air for most applications. Three of these instruments, at Mauna Loa, Little America, and La Jolla, are adapted for continuous air stream analysis. An additional instrument at the Scripps laboratory has been adapted for analyzing up to six flask samples an hour.

Over the Pacific Ocean, at Little America, at Mauna Loa, at Scripps Institution, and at several stations in the northern hemisphere where numerous flask samples have been collected, the CO_2 concentration appears to be nearly the same.

Continuous measurements at Little America show the smallest variations, about ± 0.3%. Mauna Loa shows a slightly larger variability, about ± 1.0%, and measurements during the two ocean cruises show a variation of ± 2.0%. The small degree of variability for these areas is in striking contrast to current atmospheric CO_2 measurements in Scandinavia, where a range between 250 and 400 ppm, or a variation of about 60%, is reported (see Figs. 5 and 6).

Woods Hole Oceanographic Institution Program: During August 1958, a series of 14 vertical soundings were made off the coast of Massachusetts with a CO_2 analyzer installed in the Institution's aircraft. The measurements were made east of Nantucket Island and, when weather permitted, over the Texas Tower on Nantucket Shoals. Routine meteorological observations were carried out in conjunction with the CO_2 measurements, which were taken at altitudes ranging from 100 to 10,000 ft.

The soundings indicated marked varia-

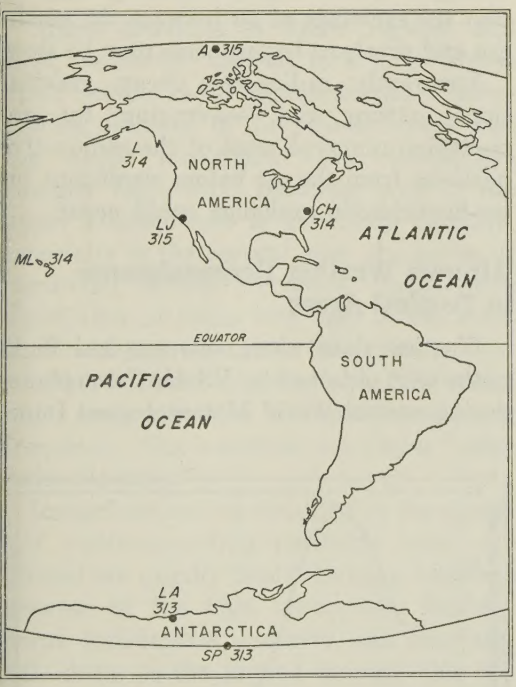

Fig. 5. *Average Index Values of Atmospheric CO_2—Spring.*

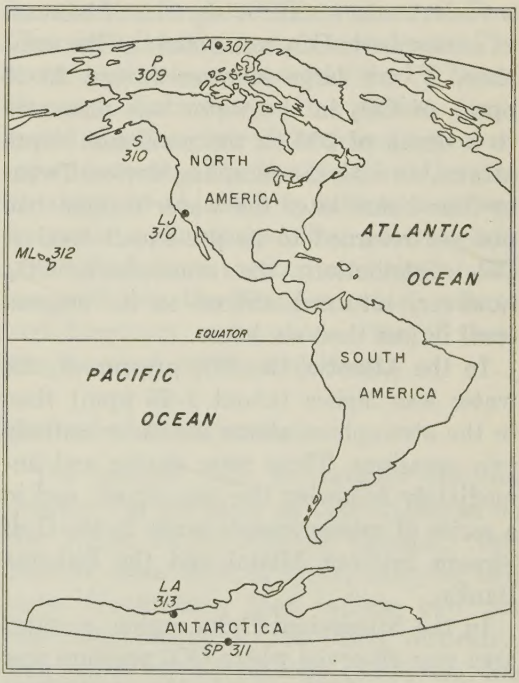

Fig. 6. *Average Index Values of Atmospheric CO_2—Late Summer and Fall.*

Note: *The index values are based on a preliminary calibration; however, variability assessment depends upon comparative values rather than upon calibration.*

Stations as follows: LA—Little America; ML—Mauna Loa Observatory; LJ—La Jolla; A—Drifting Station Alpha; CH—Cape Hatteras; L—Lark India flights; P—Ptarmigan flight; S—Stork flight; SP—South Pole.

tions of CO_2 content with altitude, as previously noted in other areas. At Nantucket, an average difference of 10 ppm was found from top to bottom of the profile, and larger variations were common. A CO_2 minimum was often noted between heights of 1000 and 3000 ft.

No correlation has as yet been found between CO_2 values and the various factors of air-mass identification, such as mixing ratio. However, the persistence of a given vertical CO_2 pattern over a period of three or four days was noted when meteorological conditions in the area were similarly persistent.

Texas Agricultural and Mechanical College Program: On the IGY cruise of the Texas A & M research vessel *Hidalgo,* continuous measurements of atmospheric and oceanic CO_2 pressures, particularly near the sea-air interface, were taken. An interesting series of observations was made during a violent rain squall. A significant increase in atmospheric CO_2 was noted; at the same time, a very large increase (about 20–50 ppm) of CO_2 in the water was measured to a depth of 200 ft, the maximum depth attainable with the sampling device. Twenty-four hours later the water column had not yet returned to its pre-squall level of CO_2 distribution; the atmospheric CO_2, however, returned almost to its original level in less than six hours.

In the Atlantic, the CO_2 pressure in the water was higher (about 1–25 ppm) than in the atmosphere above the water on only two occasions. These were during and immediately following the rain squall, and in a series of measurements made in the Gulf Stream between Miami and the Bahama Banks.

In the Mississippi Delta region, a water area was observed where CO_2 pressure was greater than 1000 ppm. In the atmosphere just above, a decrease in the CO_2 pressure was detected between air samples taken at 2 in and at 25 ft above the surface. These conditions, encountered when the ship was cruising downstream at 10 knots, persisted for about one hour. Both upstream and downstream from that area, conditions were more nearly normal for rivers: i.e., while the water had a higher CO_2 pressure than did the open Gulf or the Atlantic, it had a lower pressure than the air above it.

Nuclear Radiation

The Naval Research Laboratory conducted a program of daily air-filter collections at 20 stations along the 80°W meridian from Thule, Greenland, to Punta Arenas, Chile, in cooperation with the Weather Bureau and the meteorological services of several other nations. (See *Bulletin No. 14* for background on other phases of the IGY nuclear radiation program.)

Very little fission-product radioactivity was found south of the equator (see Fig. 7). Since most of the fission products were injected into the atmosphere in the northern hemisphere, the negative finding suggests that the exchange of air between the northern and southern hemispheres may be slow.

Apparently, radioactive decay, gravitational settling, and "scavenging" by precipitation removed most of the radioactive particles from the air before significant inter-hemispheric exchange could occur.

Aircraft Weather Reconnaissance in Tropical Areas

Weather data along two tropical flight paths were obtained by US Air Force planes during several World Meteorological Inter-

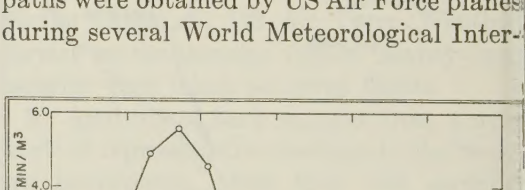

Fig. 7. *Average Fission-Product Concentration in the Atmosphere During February 1958 Along the 80°W Meridian. Profiles for other months show a similar trend.*

vals (IGY-designated 10-day periods including either a solstice or an equinox).

Twenty flights, two per day, were made between Puerto Rico and North Africa during the period March 16–27, 1958, partly at 6000 ft and partly at 20,000 ft. A total of 16 dropsondes (soundings of temperature, pressure, and humidity telemetered by instruments parachuted from the aircraft) were made along the route.

A more southerly "Special Tropical Track," from Puerto Rico to about 33°W, 13°N and return, also was followed. Four flights at 10,000 ft were made on September 18 and 26 and December 12 and 18, 1957. On each flight, 13 dropsondes were made.

An important unknown of the tropical atmosphere has been the height of the trade-wind moist layer. Graphs of the horizontal variation of the moist layer, based on data obtained in the tropical weather reconnaissance program, are being studied in relation to perturbations in easterly trade winds, some of which develop into hurricanes.

Rocket Studies of the Arctic Ionosphere

The following material was supplied by J. C. Seddon and J. E. Jackson, US Naval Research Laboratory, Washington, D. C.

Man's activities in Arctic regions, and even his safety, depend to a large extent upon reliable radio communications. Information obtained in the past indicates that the Arctic ionosphere (the electrically-charged, radio-wave reflecting layer of the upper atmosphere) is extremely variable, especially in the auroral zone, the region of maximum auroral frequency. Radio-wave absorption, at times very high in this zone, is almost unpredictable. Occasionally, absorption becomes so severe that long-range radio communication is impossible on any frequency. This condition is called a "polar radio blackout."

Ionosphere records obtained by the standard radio-sounding methods from the ground are usually blank during a blackout because of the high absorption. Rocket-borne instruments, however, can send signals down to the ground through this absorbing blanket, supplying information on the absorption and on electron densities at different altitudes; thus, such rocket experiments may supply clues for development of communications procedures to circumvent the effects of a blackout.

The first measurements of electron density ever made during a polar blackout were obtained by two of the rockets launched under the IGY program at Fort Churchill, Canada, in the auroral zone. The launchings were conducted by the US Naval Research Laboratory. One rocket penetrated the E-region of the ionosphere during a blackout. (The E-region, from heights of about 90 to 130 km, reflects medium-frequency radio waves.) Two other rockets reported on here reached altitudes of 235 km, well into the F-region, which reflects high-frequency radio waves. One of these was launched during a blackout.

Method of Observation

The method used to measure electron density was the same as that employed at the White Sands Proving Ground, New Mexico, since 1946. A rocket carrying two radio transmitters that radiate two unmodulated signals is fired nearly vertically. One signal has a frequency of 7.75 mc; the other is six times higher and the ionosphere has essentially no effect on it. This higher frequency, therefore, serves as a reference frequency.

Both frequencies experience a Doppler shift, a seeming shift in frequency which

occurs when a transmitter is moving toward or away from the receiver. This shift is observed at the ground as a decrease in frequency on the up leg of the rocket flight and as an increase on the down leg; however, the lower frequency is shifted a different percentage when the rocket is in the ionosphere than when it is beneath the ionosphere.

Ground stations located near the launcher at Fort Churchill receive the two frequencies. After the 7.75-mc signal is multiplied by a factor of six, the signals are compared. The difference is then used to compute the index of refraction (the ratio of the signal velocity in the medium to its velocity in a vacuum). The electron density required for this index of refraction can then be derived.

Results

Electron density profiles for the three flights are shown in Figure 9. Profiles A and B show electron densities and differential absorption during polar blackouts; profile C shows the electron density for a winter midnight without a blackout. (Differential absorption is the difference in absorption across a given region of the ionosphere experienced by the two components of a radio wave, ordinary and extraordinary, as they travel through it. The components are analogous to the similar components of light traveling through a doubly-refracting medium.)

Profiles A and B indicate an unusually high electron density in the D-region during the polar blackouts, mainly between 58 and 78 km. The curves show very few abnormalities for the E- and F-regions. For the region above 130 km, the curves are extremely smooth, indicating that the ionosphere was stable and free of irregularities in spite of the blackouts. Differential absorption during the polar blackouts, as shown on graphs A and B, reached a maximum at about 67 km.

Profile C shows the very low D- and E-region electron densities characteristic of

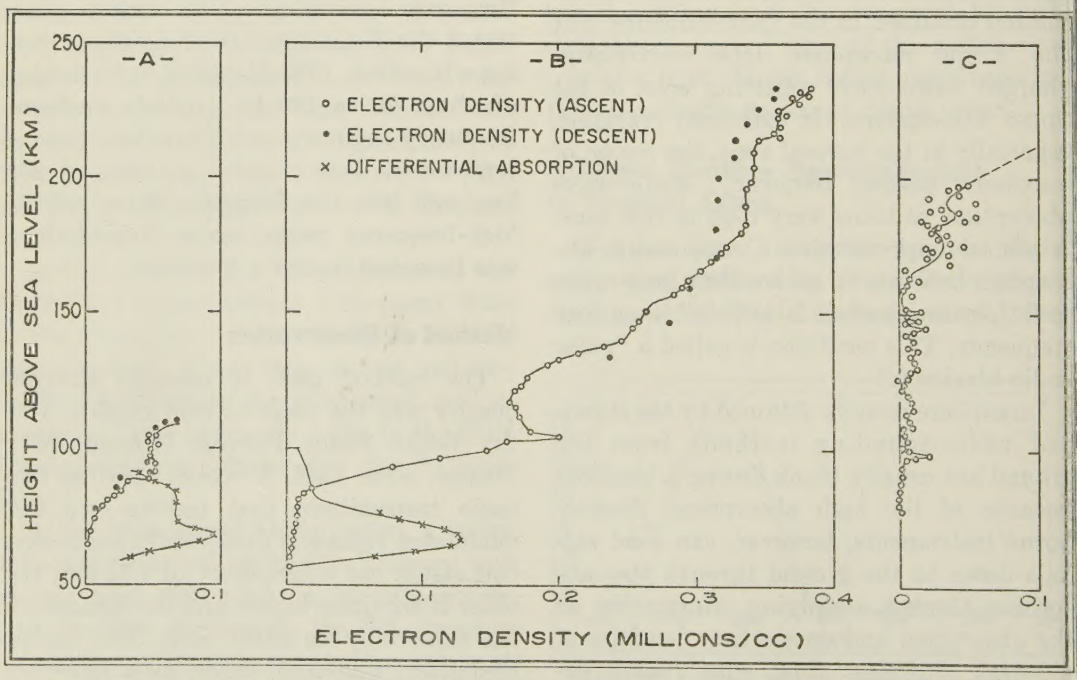

Fig. 9. *Profiles of Electron Density and of Differential Absorption at 7.75 mc over Fort Churchill. Profile A is based on a rocket flight at 1332 CST, Nov. 15, 1956; B on a flight at 1216 CST, Jul. 4, 1957; and C at 0017 CST, Feb. 4, 1958. Curves B and C represent extreme conditions: summer noon and winter midnight.*

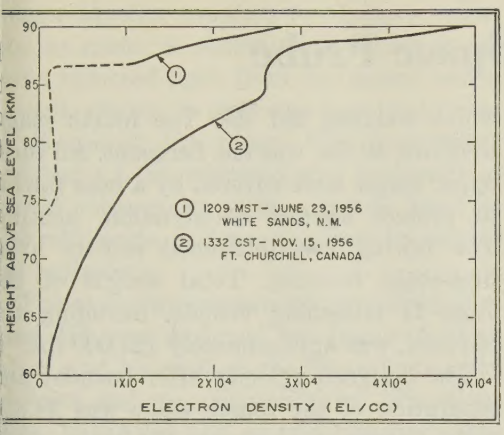

Fig. 10. *D-Region Electron-Density Profiles at Fort Churchill During a Radio Blackout and at White Sands Proving Ground, New Mexico, on a Day of Above-Normal Absorption. Dashed portion of curve 1 based on fewer data points, using Faraday rotation technique.*

he long absence of the sun's radiation. The -layer was thin, with a maximum electron ensity of only 20,000/cm³. The bottom of he F-region is evident on graph C at about 65 km.

Figure 10 compares one of the Fort hurchill profiles with a profile obtained at hite Sands on a day of above-normal ab- orption. From the indices of refraction nd the differential absorption it is possible o calculate the frequency of collisions be- ween electrons and neutral particles, as- uming an ion density of less than 10^7/cm³. he values obtained are surprisingly low or all flights, both summer and winter.

Magnetograms (records of the strength f the earth's magnetic field at the surface) how an abrupt decrease in the horizontal omponent of the magnetic field at Fort hurchill a few minutes before the launch- ng on July 4, 1957; the decrease lasted un- il well after the flight. Magnetograms and onograms obtained at this time at lower atitudes show little or no effect, indicating hat the ionospheric disturbance observed as a polar blackout only.

The three rocket flights, though not providing enough data to form final conclusions, did furnish very strong evidence that a polar blackout is due to an abnormal number of free electrons in the D-region of the ionosphere, and that moving electric charges play an important role in this phenomenon. The polar blackout seems to involve little change in the E- and F-regions of the daytime ionosphere. In addition, the daytime electron density in this region of the ionosphere is similar to that observed in lower latitudes. Further, it appears that the electron collision frequency with neutral particles may be ⅓ or ¼ that previously estimated.

It was also found that radio-wave absorption in the Arctic ionosphere varies from extremely high to extremely low values.

Additional Investigations

The data discussed in this report were obtained under a limited variety of ionospheric conditions. Hence, the scope of the program originally planned has been extended to accumulate further data.

Three additional rockets instrumented for ionospheric research were launched from Fort Churchill during November and December 1958. The data obtained are being reduced and analyzed. The first of the three, using an Aerobee-Hi, was a very successful nighttime launching directly into the center of an aurora. This was the first time electron density measurements were made in an aurora.

The remaining two launchings were attempts to obtain data above the level of maximum electron density of the F2-region (about 300 km). A new rocket, the Spaerobee, designed to reach heights in excess of 400 km carrying a newly-designed, lighter ionosphere payload, was used. The rockets attained heights of only about 100 and 200 km, but it is hoped that further efforts with this rocket-payload combination will provide the desired data.

Second IGY Space Probe

At 12:45 am EST, December 6, 1958, the fourth in a series of five US-IGY space probes, and the second to reach a substantial distance from the surface of the earth, was launched from Cape Canaveral, Florida. The probe was named Pioneer III. The launching was accomplished under management direction of the National Aeronautics and Space Administration by the Army Ballistic Missile Agency and the Jet Propulsion Laboratory of the California Institute of Technology.

Launching: The launching vehicle, a Juno II rocket system, had four stages and was 76 ft long overall. The first stage was a modified Jupiter rocket weighing approximately 120,000 lbs. The three high-speed upper stages consisted of 15 scaled-down solid-propellant Sergeant rockets developed by JPL. The second stage, weighing 721 lbs, consisted of an annular cluster of eleven of these Sergeants. Three Sergeants in a concentric cluster made up the third stage, which weighed 207 lbs. The fourth stag weighing 59 lbs, was one Sergeant. All thr upper stages were covered by a nose fairi to protect against aerodynamic heatin The fairing was jettisoned shortly aft first-stage burnout. Total weight of t Juno II launching vehicle, including t payload, was approximately 121,000 lbs.

The designed velocity after burnout an separation of the fourth stage was 24,8 mph. However, because the first sta burned out approximately 3.7 sec early, t velocity attained was about 24,000 mp Although Pioneer III did not reach its max mum objective—the environs of the mo and beyond to a heliocentric orbit—it d reach an altitude of about 63,000 statu miles.

Instrumentation: The cone-shaped, gold plated Pioneer III payload (Fig. 11), 23 i long and 10 in wide at maximum diamete was mounted atop the fourth stage. It co tained a small radio transmitter; tw

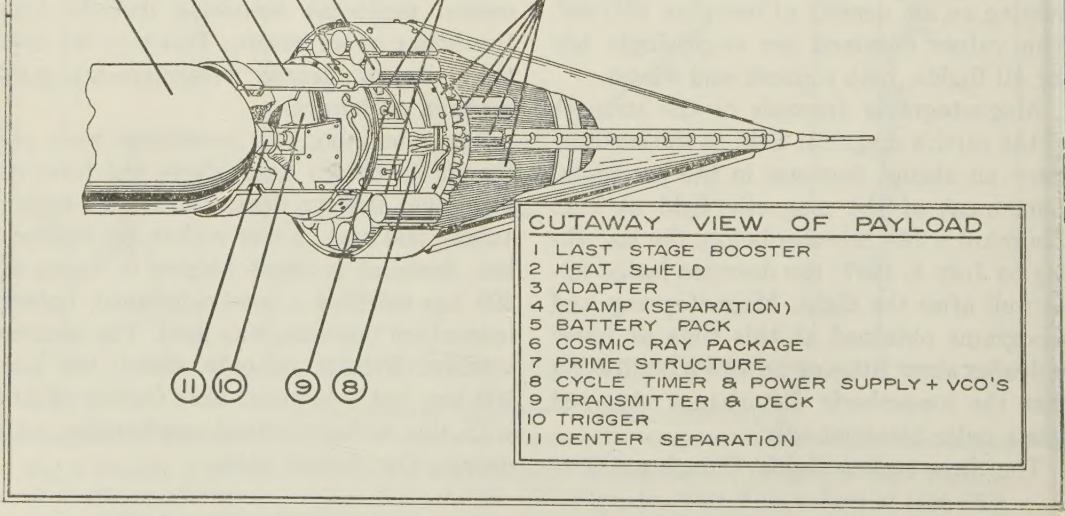

Fig. 11. *Pioneer III Space Probe. Adapted from US Army photograph.*

Geiger-Mueller counters to measure radiation in space; a photoelectric sensor to receive reflected light from the moon; and a low-spin device to slow the pay-load down as it neared the moon. The transmitter weighed 1.1 lbs, operated on a frequency of 960.05 megacycles with a power level of 180 milliwatts, and was powered by chemical batteries.

The radiation experiment carried in Pioneer III was designed by James A. Van Allen and his staff at the State University of Iowa and was engineered by JPL scientists. Van Allen and an undergraduate student assistant, Louis Frank, calibrated the radiation detectors and conducted the final pre-flight radiation calibration at the SUI physics laboratories.

Tracking: Two major stations tracked Pioneer III: a JPL tracking station at Mayaguez, Puerto Rico, and an 85-ft antenna at JPL's Goldstone Tracking Station on the California desert near Barstow.

Pioneer III re-entered the atmosphere over French Equatorial Africa, and presumably disintegrated, at 2:51 pm EST, December 7, 1958.

Preliminary Results

The data provided by Pioneer III during its 38-hour flight proved particularly valuable. It now appears that there are two radiation belts: the first is found roughly between 1400 and 3400 mi from the earth's surface, the second between 8000 and 12,000 mi.

Each of these two belts was found by Van Allen and his staff to have a very high intensity of charged particles, reaching a peak about 2400 mi out in the first belt and about 10,000 mi out in the second; a high of 25,600 counts/sec was registered. These high counts are equal to about 10 roentgens/hr, if electrons, or about 100 roentgens per hour, if protons. However, Van Allen believes it is still too early to offer a definite appraisal of whether the more penetrating component of the radiation consists of electrons or protons.

From the point of view of space travel, it remains to be seen whether acceptable means of dealing with the problem can be found. The maximum safe weekly dosage has been recommended to be no more than three-tenths of one roentgen. Between the two belts, the radiation level got no lower than three-tenths of one roentgen per hour. However, the area between the lower Van Allen radiation belt and the earth would appear to be safe for travellers for extended periods of time.

Second Conference on Ionosphere Studies Using Earth Satellites

The second conference on "Studies of the Ionosphere Using Radio Observations of Earth Satellites" was held on September 29, 1958, at the Central Radio Propagation Laboratory (CRPL) of the National Bureau of Standards (NBS) at Boulder, Colorado. (The first conference, on November 5, 1957, was reviewed in *Bulletin No. 7.*)

Organized by the USNC-IGY under the direction of A. H. Shapley, the conference provided a forum for reports on methods, techniques, and results of ionospheric experiments based on radio signals from artificial satellites. More than 50 scientists representing 16 participating institutions attended the one-day symposium, including the Ionospheric Committee of the newly-created Space Science Board of the National Academy of Sciences.

Summary reports of types of studies now being undertaken were presented by representatives of each institution. These studies

are indicated in Table 2. All experimenters are continuing the collection and analysis of data. Stanford University reported two items in process of publication. Some difficulty in data reduction has developed owing to the lack of sufficiently precise ephemerides.

Summary of Reports

—Robert Jastrow, Naval Research Laboratory, discussed a Soviet paper presented at the 5th CSAGI Assembly, in Moscow, August 1958. The Soviet paper reviewed electron-density determinations based on signals from 1957 Alpha 2 (Sputnik I) an the measurement of ion density using si nals from 1958 Delta 2 (Sputnik III).

An analysis based on the times of rad dawn (the instant the signal is heard) an radio set (the instant it disappears) gave surprisingly great scale height of 300 ± 10 km as deduced from an assumed exponenti decrease of electron density above the F2 layer maximum. (Scale height is the hypo thetical additional extent of the atmosphe above a given reference level if the tot additional atmosphere is assumed to be homogeneous density equal to that of th

TABLE 2
Ionospheric Studies Using Satellite Signals

Agency	*US-IGY Satellites*	*Sputnik III*	*Sputnik I & II* (Analysis)
Nat. Bur. Standards, Boulder, Colo.		D R P S	R
U. of Wash.	S	S	
Stanford U.		D P S A	D P A
Penn. State U.		D P S	Beginning
U. of Ill.	P S SS	P S SS	S PA (Sput. I)
Geophys. Inst., U. of Alaska		D P S	M
Geophys. Res. Directorate		Pr	OD
Linfield Res. Inst.		D R P S SS	
Cornell U.		S	SA
High Altitude Observatory			D P S
Lincoln Lab.		P	D R
Army Ballistic Missile Agency	D S		
Ballistic Research Lab.	D	D	
Army Signal Research and Development Lab.	D P	D P	D P

Experimental Code:

A: Antipodal
D: Doppler
M: Multi-Station
OD: Orbital Data
P: Polarization
PA: Propagation Anomalies
Pr: Propagation
R: Refraction
S: Scintillation
SA: Spin Analysis
SS: Signal Strength

eference level; scale height is directly proortional to the molecular temperature at ie reference level.) The integrated (per olumn of unit area) number of electrons bove the F2 maximum was found to be 3.5 mes that below. Rough estimates of the eutral-particle density, based on reasonble assumptions of the value of the recomination rate, fall exactly in the middle of model atmosphere proposed by Jastrow nd Harris for temperate latitudes at 00 km.

Ion densities of $1.8 \times 10^5/cm^3$ at 795 km nd $5.2 \times 10^5/cm^3$ at 242 km were obtained rom data gathered by ion traps in Sputik III. These densities are in good agreeient with those obtained with Sputnik I ignals and with rocket results.

—J. W. Warrick of High Altitude Obervatory (HAO), University of Colorado, oulder, Colorado, reported on the Interational Astronomical Union conference, eld in Moscow immediately following the SAGI Assembly. He briefly discussed four f the Soviet papers presented. Some of heir major points were as follows:

1a) Sputnik III measurements indicated an increase in X-ray flux above 60°N latitude.

b) Instrumentation in Sputnik III did not detect gamma-rays during solar flares on June 6, 1958.

2a) During the magnetic disturbances of May 15, 1958, ions, protons, and X-rays in the 1–100 kev range were observed by instrumentation aboard Sputnik III. A low-energy electron flux on the order of 4×10^4 ev/cm²/ster appears to be the most likely cause. (A ster, or steradian, is a unit solid angle.)

b) Rocket flights of very-high-frequency (VHF) interferometers indicate that the F2 maximum may be 50–100 km lower than usually assumed.

Warwick also reported a value of 3.8×10^{-13} gm/cc for atmospheric density at erigee of Sputnik I (about 140 mi) over Boulder from analysis of spin fading as a function of time over the life of the transmitter. Some irregularities in the curve of spin period against time are larger than the values allowed by the experimental errors. These irregularities may imply a large electrical charge in the satellite at times.

—S. J. Bauer, US Army Signal Research and Development Laboratory, reported that the rotation of the plane of polarization of radio waves (the Faraday effect) causes a characteristic type of fading of satellite signals; this can be used to determine both the integrated (up to satellite height) and local (at the satellite) ionospheric electron density if observations are made simultaneously at two or more selected locations.

—R. S. Lawrence, CRPL, NBS, Boulder, Colorado, reported on a program to determine the ionospheric effect on Doppler measurements by observing the differences in ordinary and extraordinary signal paths (see pg. 8) from satellites to a ground station. Computer programs have been developed to perform these analyses.

—B. Wieder, CRPL, NBS, Boulder, discussed observations of the systematic change with time of the Faraday fading rate using signals from 1958 Delta 2. The fading rate is slow when the satellite is to the north and increases when it is toward the south; a non-systematic fade was observed overhead. The fading rate is greater for north-south than for south-north passes. Since the satellite is higher in the sky during the north-south passes, the enhanced fading rate is apparently due to the longer ionospheric paths traveled by the signals. Nighttime passes have much slower fading rates than daytime passes.

Variations in ion concentration are indicated by differences in fading rate of as much as a factor of 3 for different satellite passes. The fading rate seems to correlate well with the square of the F2 critical frequency.

—C. G. Little, CRPL, NBS, Boulder, reported that Faraday fading times of signals

from a satellite traveling near the bottom of the F2 region increased from 1.5 to 4 sec between successive nodes, or peaks, on a pass from southwest to northeast, although many variations occurred. The lateral extent of observed irregularities in ionospheric structure was about 100 km. The integrated electron content per cm^2 column required to produce this effect was calculated as on the order of 10^9/km.

—G. W. Swenson, Department of Electrical Engineering, University of Illinois, Urbana, Illinois, presented a summary of the collection and analysis of 20- and 40-mc interferometer data for satellites 1957 Alpha 2 and 1957 Beta. A post mortem ephemeris for 1957 Alpha 2, based on time and longitude of passage of the 40th parallel, was prepared.

Good agreement was reported between this ephemeris and visual observations for October 1957. Transitions from "hashy" to regular fading, and vice versa, were observed when the satellite was both above and below the F2 maximum. They are apparently not correlated with sunrise or sunset. Abrupt changes in signal strength may be owing to characteristics of the propagation path, the number of hops, and the skip distance.

—O. K. Garriott, Stanford University, Stanford, California, described Doppler-Faraday reduction and work on ionospheric irregularities using Sputnik III signals. On many of the records of change of signal strength with time, the time can be identified at which the ray path between satellite and receiver became approximately perpendicular to the earth's magnetic field lines. This is shown as a marked reduction in the rate of Faraday rotation, and frequently as a change from linear to elliptical polarization. Under these conditions the difference in phase-path length between the ordinary and extraordinary rays is relatively small. The difference in path length at any time can be determined simply by counting the number of fades due to Faraday rotation between the reference time and the time of interest. This permits estimating integrated electron density along the ray path.

An approximate equation indicates that the rate of Faraday rotation is proportional to the number of electrons per unit column below the satellite height. Reasonably good results may be obtained for satellite positions near its closest point of approach.

It was noted that a flutter effect in the signals may be owing to their arrival over different paths below the ionosphere rather than to ionospheric irregularities. Study of signals from the satellite's antipodes (at an Indian Ocean location) suggests tilt of the ionosphere at sunset, with possible confinement of the signals to a narrow cone of arrival.

—W. J. Ross, Pennsylvania State University, University Park, Pennsylvania, reported the accumulation of four months simultaneous recordings on the 20.0045- and 40.009-mc/s transmissions of 1958 Delta 2; the recordings were made at each of three stations several hundred miles apart. Data reduction and analysis are proceeding. Doppler data are being reduced; polarization and scintillation effects are being generalized; and some observed phase-path scintillation between 20 mc/s and 40 mc/s, presumably owing to irregularities in the propagation path, is being investigated.

—T. E. Van Zandt, CRPL, NBS, Boulder, spoke on the calculation of true heights of electron-density levels based on ionization effects. Large inaccuracies were found. Unobserved low-density ionization was reported to be the primary cause of error and it was concluded that true-height values for the transition periods, about an hour after sunset and before sunrise, are especially uncertain. An improved method of calculation expected to provide true-height values accurate to within 5–10 km, was to be put into use about January 1959.

—P. R. Arendt of the US Army Signal Research and Development Laboratory reported that the Laboratory has observed

arly all passages of all artificial satellites ming within reach of the receiving station Deal, New Jersey. A library of more an 4,500 recordings (on magnetic tape d on paper charts) is available. Final aluation of the data depends on the exist- ce of fairly precise ephemerides giving sition and altitude of the satellites for ne intervals of one minute or less. Only cently have such data been made avail- le. Meanwhile, evaluation based on ob- rvations of the fading periods produced the Faraday effect have been made. ch observations enable determination of ether the satellite moves in zones of ual or varying electron density or whether the vehicle is in zones where no magneto-ionic effects are created.

Observations of 1958 Epsilon (Explorer IV) also indicate strong magneto-ionic effects at altitudes between 1000 and 2000 km. These findings coincide with the results of moon-echo observations made in the Signal Research and Development Laboratory which indicate that 75% of the observed Faraday rotation might be due to effects occurring on top of the F-layer maximum.

Shapley urged institutions to submit proposals and suggestions for ionospheric experiments to the Space Science Board's Committee on the Ionospheres of the Earth and Planets.

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